LONG ISLAND WATER RESOURCES
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ARTIFICIAL RECHARGE ON LONG ISLAND, NEW YORK

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U.S. Department of the Interior
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TO INTERNATIONAL SYSTEM (SI) UNITS

U.S. Customary units	Multiply by	SI units
feet	.3048	meters
yards	.9144	meters

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ABSTRACT

In eastern and central Long Island, the ground-water supply has been diminished by the demands of continued population growth and the loss of replenishment since the advent of sewering. In addition, the quality of ground water is threatened locally by the discharge of effluents from septic tanks, cesspools, and industries and by salt-water intrusion near the shorelines as a result of heavy pumping.

The use of highly treated wastewater (reclaimed water) to replenish the ground-water supply on Long Island seems to be both feasible and economical. Two methods that have been tested are injection of reclaimed water into the ground through wells, and ponding it in basins for infiltration to the water table. Major hindrances to these methods are well clogging by suspended particles in the injectant and clogging of the infiltration surface of the basin. Both can be controlled by adequate treatment of reclaimed water prior to recharge and by proper maintenance of infiltration surfaces.

Artificial recharge can be made safe through monitoring of (1) chemical quality of ground water and of the reclaimed water as it is injected; (2) water-table levels as they rise in response to recharge; (3) changes in volume of streamflow and in chemical quality of streams near recharge operations, and (4) chemical quality of coastal waters that receive streamflow from the island.

INTRODUCTION

Ground water is the sole source of fresh water for the nearly 2.8 million inhabitants of Nassau and Suffolk Counties, Long Island, N.Y. In recent years, rapid growth in population and urbanization in this part of the island has increased both the demand for fresh water and the amount of wastewater discharged to the ground through septic tanks and cesspools. The discharge of increased amounts of wastewater to the ground now threatens the chemical quality of the ground-water supply, and the problem has become a matter of vital concern for water managers and the residents of Long Island. Because ground water will continue to be the sole source of fresh water for most of Long Island for at least the next several decades, methods of preserving this resource are being sought and investigated.

This booklet, prepared in cooperation with the Nassau County Department of Public Works, was written to describe in nontechnical terms one approach that might be taken as a part of the water-resources management of Long Island, namely "artificial recharge," or the use of reclaimed water (highly treated wastewater) to replenish the ground-water supply. The sections that follow explain the basic principles of artificial recharge and the various approaches to it; they also describe present and planned artificial-recharge studies on Long Island.

General information on the water situation on Long Island can be found in "An Atlas of Long Island's Water Resources" (Cohen and others, 1968). One section of that publication describes, in broad terms, several methods of developing and managing the island's water resources, including artificial recharge.

This booklet was produced as part of a continuing long-term program of water-resources studies on Long Island made by the U.S. Geological Survey in partnership with local, county, and New York State agencies.

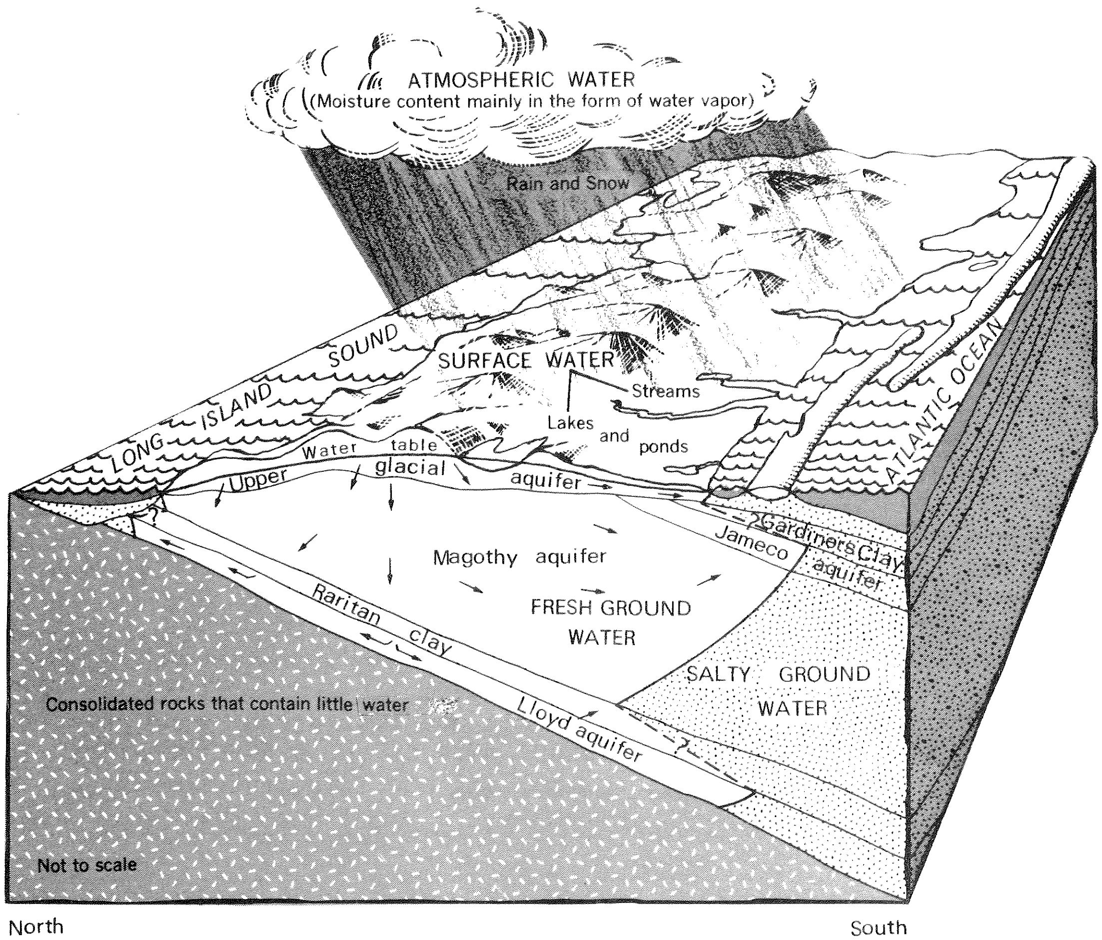

Figure 1.--Cross section of Long Island showing sources and types of water, major hydrogeologic units, and paths of ground-water flow. [Modified from Cohen and others, 1968.]

HYDROGEOLOGY OF LONG ISLAND

Long Island is underlain by a thick, southward-dipping wedge of rock materials that consist mainly of sand, silt, clay, and gravel (fig. 1). These loose materials are underlain by dense crystalline bedrock that does not store or transmit significant quantities of water. The ground-water reservoir is within the loose (unconsolidated) materials above bedrock; its upper surface is known as the water table. The water table generally parallels land surface but with less pronounced rises and depressions; thus, it is highest beneath the hills near the middle of the island and lowest near the shorelines. The water table is at the land surface in lakes, marshes, and at the shore but may be more than 100 feet below the land surface beneath the hills. The ground-water reservoir on Long Island ranges in thickness from 0 feet in northern Queens County, where bedrock is exposed, to more than 2,000 feet in south-central Suffolk County.

The materials that form the ground-water reservoir can be classified into several hydrogeologic units[1] on the basis of (1) water-transmitting properties, (2) position in relation to other units or layers, (3) composition, and (4) geologic age. Hydrogeologic units in the ground-water reservoir that yield major amounts of water are called aquifers (from Latin *aqua*, water; and *ferre*, to bear). The Long Island ground-water reservoir contains four aquifers; their position in relation to major intervening clay beds, called confining beds because they retard the movement of water, is shown in figure 1. General descriptions of the deposits underlying Long Island are given in table 1.

Below the water table, the spaces between rock particles are saturated with water. Above it the deposits are generally unsaturated but contain varying amounts of moisture, part of which is the soil water that supports plant life.

Precipitation is the source of all fresh ground water on Long Island. Of the total precipitation on the island, only a small part reaches the water table; the rest either runs off the land surface into streams and to sea or returns to the atmosphere by evaporation and through transpiration by plants. Some of the water that reaches the water table moves laterally within the upper parts of the ground-water reservoir, but most of it moves downward into the middle and deep parts. The general path of ground-water movement on Long Island is seaward, as indicated by the arrows in figure 1. Some of the seaward-moving ground water discharges into streams; the remainder discharges offshore as subsurface outflow into Long Island Sound, the bays bordering the island, and the ocean.

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[1] Hydrogeologic units are rock or sediment sequences having distinctive hydrologic and geologic characteristics.

Table 1.--Characteristics of major hydrogeologic units of the ground-water reservoir underlying Long Island, N.Y.

[Modified from Cohen and others, 1968]

Hydro-geologic unit	Geologic name	Approximate maximum thickness (feet)	Water-bearing character
Upper glacial aquifer	Upper Pleistocene deposits	400	Mainly sand and gravel of moderate to high permeability; also includes clayey till of low permeability.[1]
Gardiners Clay	Gardiners Clay	150	Clay, silty clay, and a little fine sand of low to very low permeability.
Jameco aquifer	Jameco Gravel	200	Mainly medium to coarse sand of moderate to high permeability.
Magothy aquifer	Magothy(?) Formation	1000	Coarse to fine sand of moderate permeability; locally contains gravel of high permeability, and abundant silt and clay of low to very low permeability.
Raritan clay	Clay member of the Raritan Formation	300	Clay of very low permeability; some silt and fine sand of low permeability.
Lloyd aquifer	Lloyd Sand Member of the Raritan Formation	300	Sand and gravel of moderate permeability; some clayey material of low permeability.

[1] Permeability denotes how readily water can move through porous material.

ARTIFICIAL RECHARGE

What is It?

Natural recharge is the replenishment of ground-water bodies by infiltration of precipitation or surface water through the soil cover and earth materials to the water table. Artificial recharge may be defined as intentional replenishment of ground-water bodies. Although irrigation and the disposal of sewage, cooling water, or other wastewaters will replenish ground-water bodies, the replenishment is incidental to other functions. Therefore, water projects in which recharge is not a major objective are not considered artificial-recharge projects.

The primary purpose of most artificial recharge is to increase the amount of fresh ground water available. Some specific objectives of artificial recharge on Long Island are (1) compensation for natural recharge lost through sewering; (2) replacement of ground water removed through excessive pumping; (3) control or prevention of sea-water intrusion into an aquifer as a result of excessive ground-water pumping near the shores; (4) maintenance or raising of ground-water levels to avoid increased well-construction and pumping costs; (5) storage of water for use during dry periods, when the rate of natural recharge declines; and (6) filtration of reclaimed water by aquifer materials to remove impurities. These objectives are discussed in greater detail in the sections that follow.

Although artificial recharge is a potential means of alleviating certain water-supply problems, each situation calling for its use must be studied independently to determine physical and economical feasibility. Wherever an artificial-recharge installation is planned, geologic and hydrologic conditions that affect the process must be evaluated, and the most suitable method of recharge and costs of installation and operation must be determined.

Reclamation and reuse of water is being practiced for a variety of purposes and in a variety of ways throughout the world. Some of the most significant artificial-recharge projects in the eastern U.S. are on Long Island, where the need for such projects has become critical.

Need on Long Island

The increasing demand for ground water on Long Island in recent years has been accompanied by a substantial reduction in ground-water replenishment. This reduction has been caused largely by the diversion of wastewater to coastal waters since the advent of sewering.

Sewer systems have been installed on eastern Long Island (fig. 2) in recent decades to prevent wastewater from septic tanks and cesspools from contaminating the ground-water reservoir. These systems terminate in wastewater-treatment plants that discharge their effluents to the southern bays and to the ocean. Although the disposal of wastewater

into Long Island's coastal waters protects the ground-water reservoir from sewage contamination, it may also accelerate depletion of the island's ground-water supply by continually removing water that would otherwise be returned to the system.

In those parts of Long Island that lack storm-water basins--notably Queens and Kings Counties and the parts of Nassau and Suffolk Counties that were extensively developed before basins came into common use--natural recharge is further diminished by the large number and extent of impermeable surfaces, such as paved streets, buildings, and parking lots, which prevent infiltration of precipitation and thereby cause ground-water levels to decline locally. In these areas, storm runoff is wasted to Long Island's coastal waters through storm sewers instead of seeping into the ground to replenish the ground-water reservoir.

Another problem associated with the increasing demand for ground water is the intrusion of sea water into the aquifers in coastal areas where ground-water levels have declined. Excessive pumping of wells in such areas draws salty water landward to replace the fresh water removed from the island's aquifers.

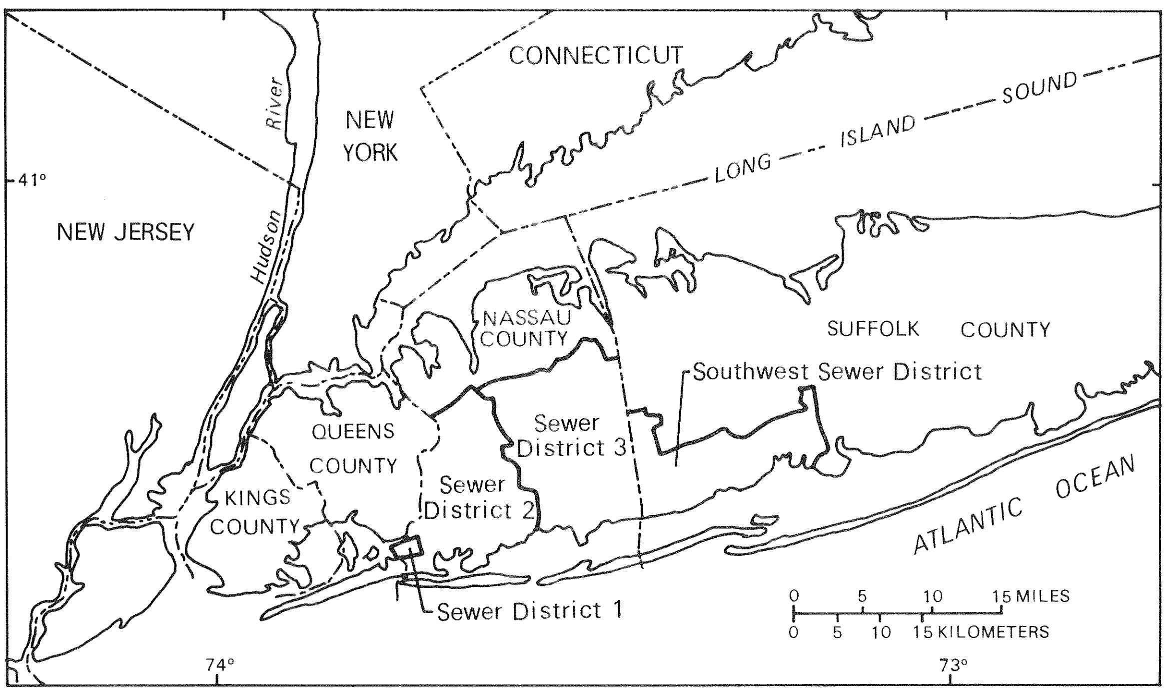

Figure 2.--Locations of selected sewer districts in Nassau and Suffolk Counties.

Unless appropriate steps are taken soon, water quality in unsewered areas of Long Island will continue to deteriorate as a result of sewage disposal to the ground, and ground-water levels in sewered areas will continue to decline. Lowered ground-water levels, in turn, cause a reduction in length and volume of streamflow because the streams of Long Island are fed by ground water. If, in the future, the ground-water reservoir can be artificially replenished, the amount of potable ground water available for withdrawal will be increased, ground-water levels and streamflow can be maintained, even in sewered areas, and sea-water intrusion into the aquifers can be slowed. Furthermore, artificial recharge can improve the chemical quality of ground water to the extent that recycled water is chemically and biologically superior to the cesspool and septic-tank effluents now filtering into the ground-water reservoir.

Thus, if the island's wastewater can be treated to remove contaminants and can be returned to the ground-water reservoir in sufficient volume, it will replenish and improve the ground-water supply and thereby extend its usefulness.

Feasibility

Artificial recharge with highly treated wastewater is successfully practiced throughout the world and has become accepted in many communities of the U.S. The quality and safety of community water supplies in this country are considered to be among the best in the world, and public-health statistics indicate that water-borne disease has been almost eliminated in this country. This favorable situation can be attributed primarily to the effectiveness of water-treatment plants and, in certain areas, to the proper design, operation, and control of artificial-recharge systems.

The feasibility of artificial recharge on Long Island has been demonstrated through successful long-term use of inground waste-disposal systems, storm-water basins, and injection wells. The fact that untreated wastewater has been discharged into the ground through septic tanks and cesspools since the arrival of the first European settlers without causing apparent viral or bacterial contamination of Long Island's ground-water reservoir would seem to indicate that reclaimed water, which can be made to meet virtually all drinking-water standards, should likewise pose no health hazard as long as adequate precautions are taken.

Artificial recharge on Long Island is also greatly facilitated by the ability of the sandy soil and subsurface of most of the island to accept and transmit water rapidly. Since the 1930's, basins have been used to intercept large quantities of storm runoff that would otherwise have been discharged to coastal waters. Most of the more than 2,200 basins commonly dispose of all runoff within several hours after a storm.

Also, large volumes of treated wastewater have been returned to the ground-water reservoir by means of injection wells and recharge basins at sewage-treatment plants and artificial-recharge sites in Nassau and Suffolk Counties. Names and locations of some of these sites are shown in figure 3.

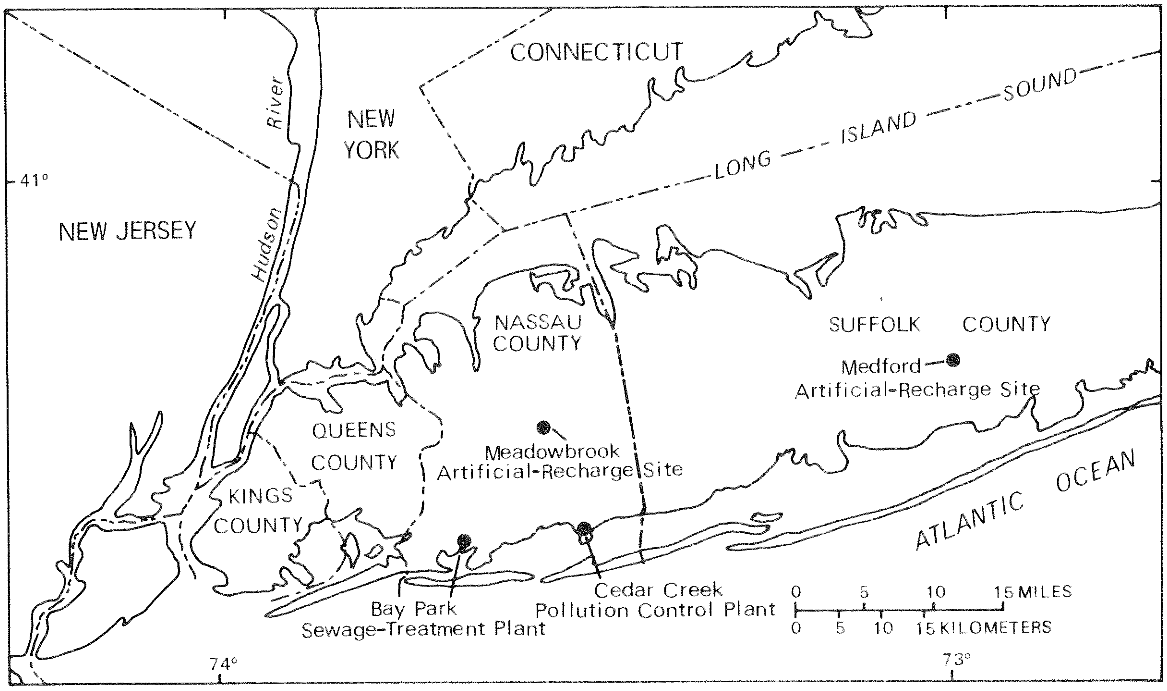

Figure 3.--Locations of selected artificial-recharge sites and sewage-treatment plants in Nassau and Suffolk Counties.

Methods

In areas such as Long Island that are underlain by unconsolidated deposits, the most efficient methods of artificial recharge take advantage of the porous and permeable character of the subsurface materials. Generally, the recharge water flows both horizontally and vertically away from where it enters the ground-water reservoir and commonly is recovered only after it has traveled hundreds or thousands of yards through aquifers.

Two methods of artificial recharge particularly well suited to Long Island are (1) ponding on the land surface to permit water to infiltrate downward through the soil and to the water table; and (2) injecting water into wells. Whether reclaimed water is returned to the ground by ponding or through injection wells, it is purified by

filtration as it moves through aquifer materials, and dilution by recharge from precipitation further improves its chemical quality by lowering the concentrations of dissolved chemicals that may have built up from continued reuse.

Water Ponding

Artificial recharge by ponding of water in basins is well suited to Long Island, as demonstrated by more than 2,200 storm-water basins, which, since their inception in 1934, have effectively disposed of many hundreds of millions of gallons of storm runoff. A typical storm-water basin is shown in figure 4.

Figure 4.--Typical storm-water basin in Nassau County. Water from storm sewers enters through pipe in far corner.

Elsewhere in the U.S., water ponding in basins is the most commonly used method of artificial recharge because the basin floors can be easily cleaned to maintain infiltration rates, and the floor and walls provide a relatively large surface for infiltration. Basins have the further advantage of being operable with water of lower chemical quality than that used for injection because the several feet of soil overlying the water table provide effective filtration.

One disadvantage of recharge by ponding is that it requires control of algae, insects, and weeds, as well as regular removal of clogging material from the basin floor. Another problem, particularly on Long Island, is the difference between the vertical and horizontal permeability of the aquifers. Because water is transmitted horizontally more readily than vertically, water returned to the shallow aquifer may not reach the deeper aquifers as rapidly as it is pumped from them, which could cause water levels in the deeper aquifers to decline.

Injection Wells

Injection of water into wells designed specifically for artificial recharge has been practiced for many years in this country with varying degrees of success. The use of injection wells is largely confined to (1) areas where surface spreading is not feasible because clay or other impermeable materials overlie the principal water-bearing beds, or (2) areas where land values are prohibitively high. At Bay Park in Nassau County, an experimental installation for deep-well injection of reclaimed wastewater (fig. 5) has been used to recharge the Magothy aquifer and to determine the feasibility of creating a freshwater barrier to hinder or prevent sea-water intrusion.

In general, recharge by means of wells is more costly than surface-spreading operations and involves the risk that, in bypassing the soil cover and its beneficial filtering action, reclaimed water may clog the aquifer or contaminate the ground-water supply through chemical reactions with the aquifer materials or ground water. However, injection wells have certain advantages over basins in that they require little land area, and the water can be injected into an aquifer near the zone of maximum withdrawal, which minimizes the effect of low vertical permeabilities.

METHODS OF WASTEWATER RECLAMATION

Wastewater used in artificial recharge must first be treated thoroughly to remove contaminants that could pose a health hazard and to remove particles that would retard its flow into the ground.

Sewage or wastewater may be treated by any of several methods for reuse, depending on the intended purpose. One practice is to partially treat municipal wastewater for direct use in industry or agriculture; another, which is especially suitable for Long Island, is to use highly treated wastewater for artificial recharge of the ground-water reservoir.

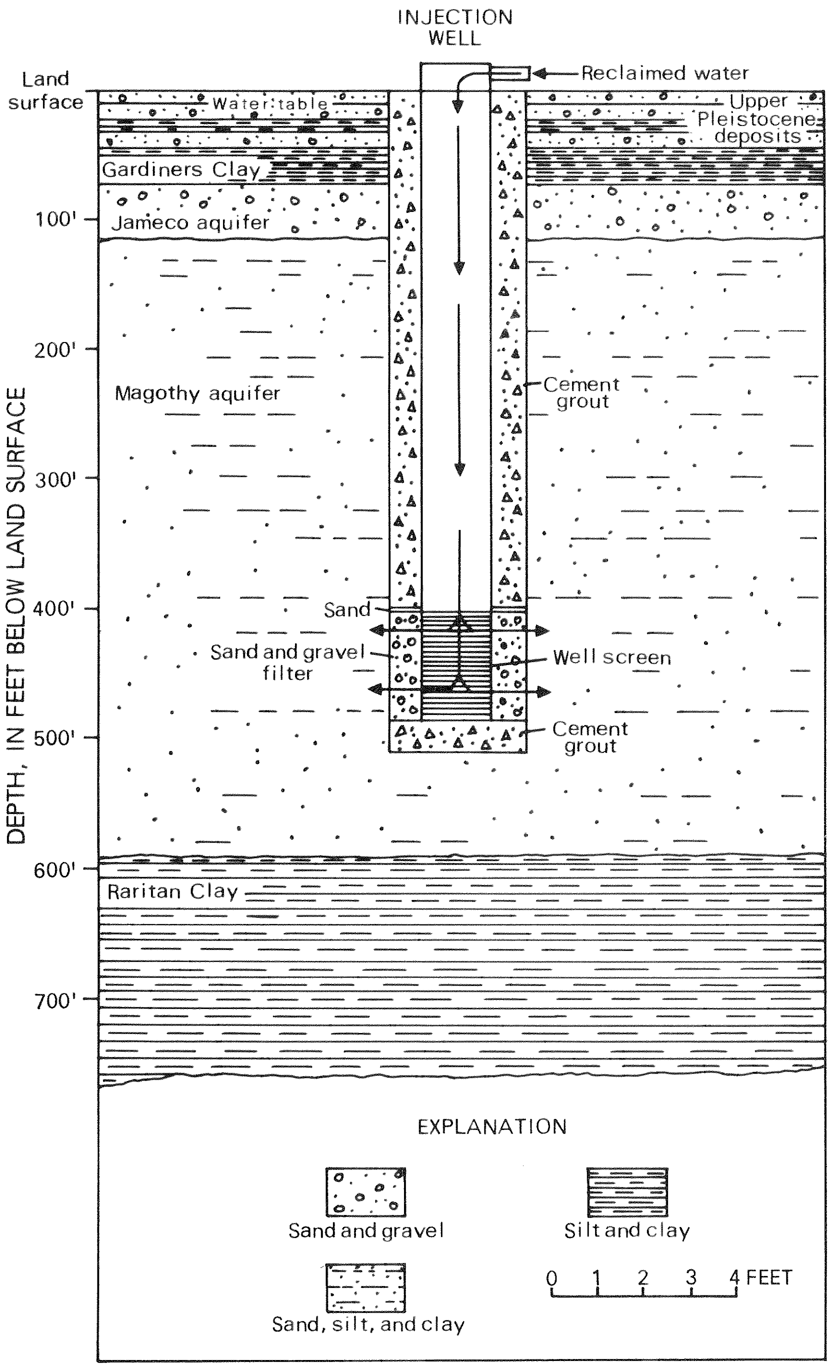

Figure 5.--Generalized cross section of injection-well installation at Bay Park, Nassau County.

The Bay Park Sewage-Treatment Plant in southern Nassau County (fig. 3) is an example of a facility that can treat wastewater for artificial recharge. At this plant, wastewater is treated by the "activated-sludge" method[1] and is discharged to coastal waters. From 1968-73, a demonstration tertiary-treatment facility at the plant further purified about 600,000 gallons of effluent per day for reuse by deep-well injection.

Tertiary treatment at the demonstration facility consisted of (1) coagulation and sedimentation of materials not removed by the activated-sludge treatment; (2) dual-media filtration through a sand-anthracite filter to remove residual suspended organic and inorganic solids, (3) activated-carbon adsorption by a series of four carbon columns to remove remaining adsorbable organic substances; and (4) chlorination to destroy bacteria. Additional treatment at the injection facilities included removal of dissolved gases and adjustment of pH. The reclaimed water produced by this process met almost all accepted drinking-water standards and was injected through a 480-foot-deep injection well near the treatment plant. Figure 5 shows the injection-well configuration.

FACTORS AFFECTING RECHARGE RATES

Clogging of Infiltration Surfaces

Because the cost of land on Long Island is high, artificial recharge by ponding requires a high infiltration rate to provide efficient land use. Infiltration rates at ponding sites tend to decrease with time, especially if the reclaimed water does not receive adequate treatment. Decreases in infiltration rate can be attributed to (1) swelling of soil particles after wetting, and (2) clogging of the soil pores by high particulate concentrations or by microbial growths. Generally, recharge rates vary in proportion to average soil-particle size in a ponding area. A soil-column study (fig. 6) underway at the site of the Bay Park tertiary-treatment plant since 1975 is concerned with the causes of soil clogging during infiltration of reclaimed water in soils of the type that underlie Long Island storm-water basins. Results of this study will be used as a guide to water management in the operation of existing and future artificial-recharge projects on Long Island and elsewhere.

Clogging of Injection Wells

Most problems in maintaining recharge rates in injection wells are caused by clogging of the well screen and aquifer. In general, principal causes of clogging are suspended particles in the injected water, products of microbial activity within the well, chemical reactions between injected water and the ground water, and air entrapment in the aquifer

[1] A process whereby a mixture of sewage or wastes and activated sludge is agitated and aerated to oxidize organic matter. The activated sludge consists of settled sewage or waste produced by the growth of bacteria and other organisms in the presence of oxygen.

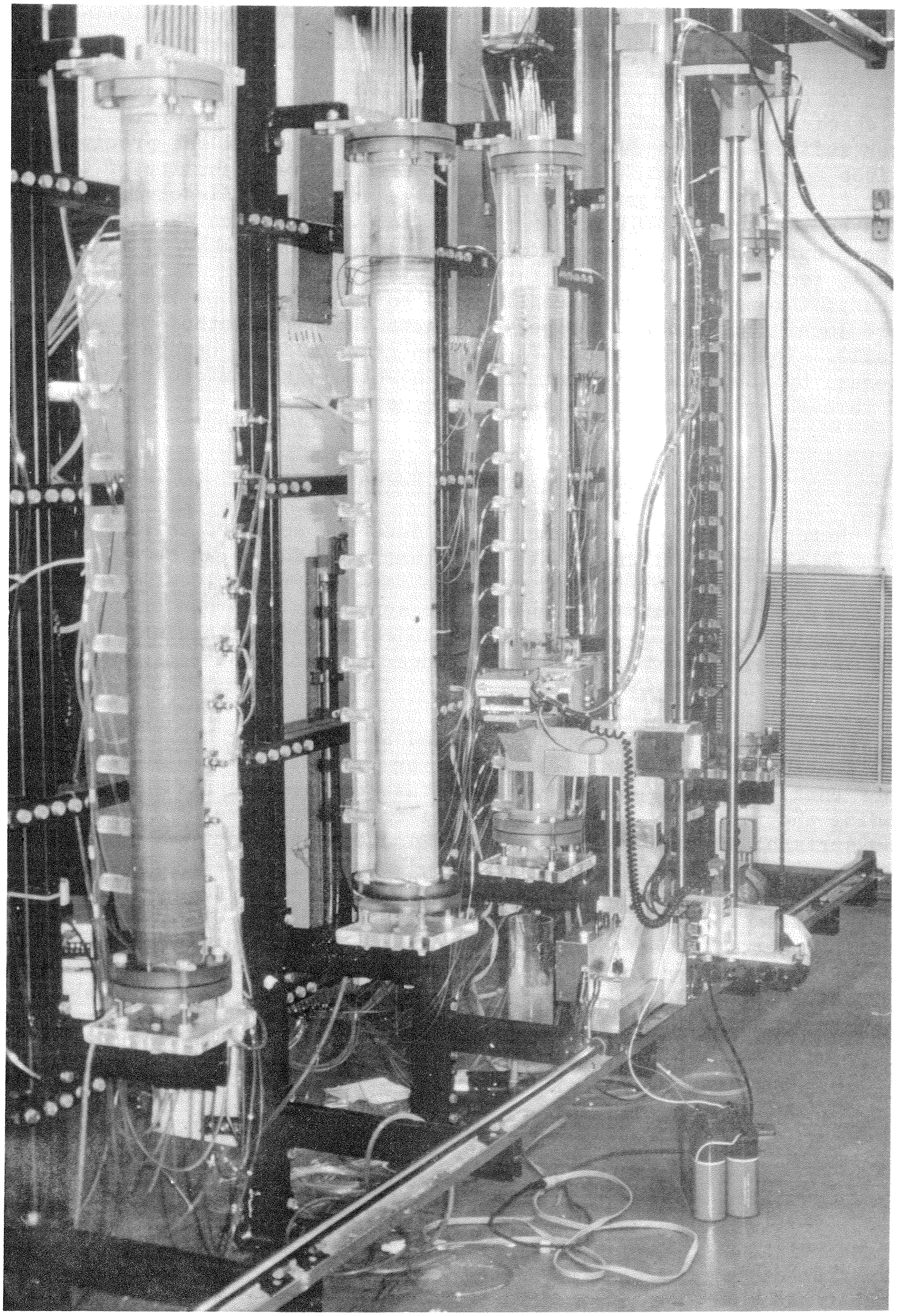

Figure 6.--Part of soil-column study laboratory at Bay Park.

Reclaimed water that has not been properly disinfected may contain bacteria that adhere to the well screen and the aquifer materials. As the bacteria multiply, they tend to reduce the ability of the screen and aquifer to transmit water. Another type of well clogging may occur when the chemical quality of reclaimed water differs from that of the ground water sufficiently to cause chemical reactions, such as the precipitation of iron compounds, which may reduce porosity and permeability of the aquifer. Reclaimed water may also carry large amounts of dissolved air, which tends to reduce permeability of the aquifer when bubbles become entrapped in pore spaces. The above factors, individually or combined, can significantly reduce recharge rates through injection wells[1]. As a result, recharge through wells has been limited to those areas of the world where local conditions and experience have shown the method to be practicable. The effect of these factors on recharge rate can be minimized, however, by adequate treatment of the injected water before recharge and through proper well treatment where needed.

Treatment to Increase Recharge Rates

Where the flow of reclaimed water into the soil and to the water table is slowed, soil treatments and other procedures can be applied to increase soil permeability and recharge rates. Proper treatment of the reclaimed water to retard clogging also serves to maintain or to improve infiltration rates during ponding and injection; chlorination and filtration of reclaimed water effectively reduce bacteria and sediments that may clog the soil pores.

Procedures developed on Long Island and elsewhere to maintain high infiltration rates include (1) tilling or scarifying (scraping) a basin floor that has become clogged by detritus or microbial activity; (2) ponding the reclaimed water deeply to increase pressure at the infiltration surface; (3) mulching the soil to increase porosity and permeability; (4) using chemicals to increase permeability; (5) covering the fine-grained native material on the floor of the basin with coarse sand or gravel to help maintain infiltration rates over a longer period of time; and (6) planting vegetation on the infiltration area to increase soil porosity and permeability and to provide root channels through which water can percolate. Scarification operations at a storm-water basin are shown in figure 7.

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1 Reduced rates of recharge during certain phases of the Bay Park artificial-recharge project were caused by suspended particulate matter in the reclaimed water. Almost no microbial clogging, air entrapment, or unfavorable chemical reactions between native ground water and reclaimed water occurred.

In deep-well injection, the most common cause of decreased injection rates is clogging of the well screen or the aquifer in the vicinity of the well screen. The two most commonly used methods of improving recharge capacity of injection wells are (1) surging (causing the water to flow in alternating directions) to loosen clogging materials, and (2) treating well screens and the aquifer material directly around them with acid or other chemicals to dissolve clogging materials. These methods were used with varying degrees of success at the Bay Park injection-well facility.

Figure 7.--Scarification operations at a storm-water basin in Nassau County.

FACTORS IN SELECTION OF ARTIFICIAL-RECHARGE SITES

The success of an artificial-recharge project may depend largely on its location. Because the physical and hydrologic characteristics of the subsurface deposits determine recharge rates, selection of a new site or evaluation of an existing one requires detailed knowledge of the local geologic and hydrologic conditions. On Long Island, as elsewhere, sites underlain by highly permeable glacial sand and gravel deposits have higher recharge rates than sites underlain by poorly permeable till, which consists largely of clay and silt. Other factors that must be known in order to evaluate the location of a recharge site include:

1. altitude of the water table, for this helps determine the maximum rate and duration of recharge that could be used before the water table would rise to the land surface;

2. location of fine-grained and (or) poorly permeable layers, for these can form barriers to the vertical and lateral movement of water;

3. rate at which the subsurface deposits transmit water, for this governs the rate at which the added water moves away from recharge sites to permit further recharge;

4. distribution and timing of pumping, for these influence the movement of water through the ground-water reservoir;

5. location of the recharge site with respect to water-supply wells, for this determines the distance the recharge water will travel before reuse and therefore the extent to which it is filtered;

6. proximity of the recharge site to the sewage-treatment plant supplying recharge water, for this determines to a large extent the cost of water-transmission mains;

7. costs of securing necessary lands and rights-of-way; for these costs may dictate the method of recharge and determine the economic feasibility of the entire project;

8. anticipated land use adjacent to the proposed recharge site, for this may influence modes of operation and maintenance.

Each recharge site poses a unique set of problems that must be thoroughly investigated. When one considers the variation among (1) soils, (2) physical and hydrologic characteristics of subsurface deposits, (3) depths to ground water, and (4) chemical quality of reclaimed water, in addition to all other factors that affect the movement of water into and through soils and underlying materials, it is little wonder that no two recharge projects are likely to proceed in the same way.

SAFEGUARDS NEEDED IN ARTIFICIAL RECHARGE

The widespread acceptance of water reclamation and artificial recharge can be attributed in large part to the growing public awareness of the need for conservation of natural resources and preservation of environmental quality, and to the fact that, thus far, no adverse health effects have been associated with this practice in the U.S. Nevertheless, the public must be assured that waste-treatment systems are designed and operated to produce reclaimed water of acceptable quality so that no harmful substances are introduced into the ground-water reservoir.

Prudent management of Long Island's water resources requires many safeguards and extensive monitoring systems. As a major part of the island's water-management program, artificial-recharge operations and their effects on the island's hydrologic system will also require careful observation.

Wastewater Disposal

A desirable feature for any artificial-recharge system is a provision for alternative methods of disposal when the quality of reclaimed water is unacceptable or when the water is not needed. To this end, Nassau County's Bay Park Sewage-Treatment Plant and Cedar Creek Pollution Control Plant (fig. 3) were designed so that reclaimed water can be diverted to the ocean.

Water Quality

The water used in artificial recharge needs continuous monitoring to insure that it meets specified chemical, biological, and physical standards and to assure that no harmful substances are introduced into the ground-water reservoir. Additional monitoring of ground water in the vicinity of recharge sites and at selected distances therefrom are needed to detect any unfavorable chemical reactions between reclaimed recharge water and the ground water and to trace the movement of reclaimed water as it moves through the hydrologic system.

Water-Table Altitude

Monitoring the water-table altitude is necessary during artificial recharge to determine (1) the magnitude and areal extent of the water-table mounds that develop beneath recharge sites (fig. 8), and (2) the degree of regional water-table rise, so that excessive buildups can be prevented in areas where the water table is close to land surface.

Streamflow and Stream Quality

Monitoring major streams is necessary to determine increases in streamflow and stream length and the changes in stream-water quality during artificial recharge. Monitoring the coastal waters that receive streamflow is also necessary to determine effects of improved ground-water quality and increased streamflow from the island.

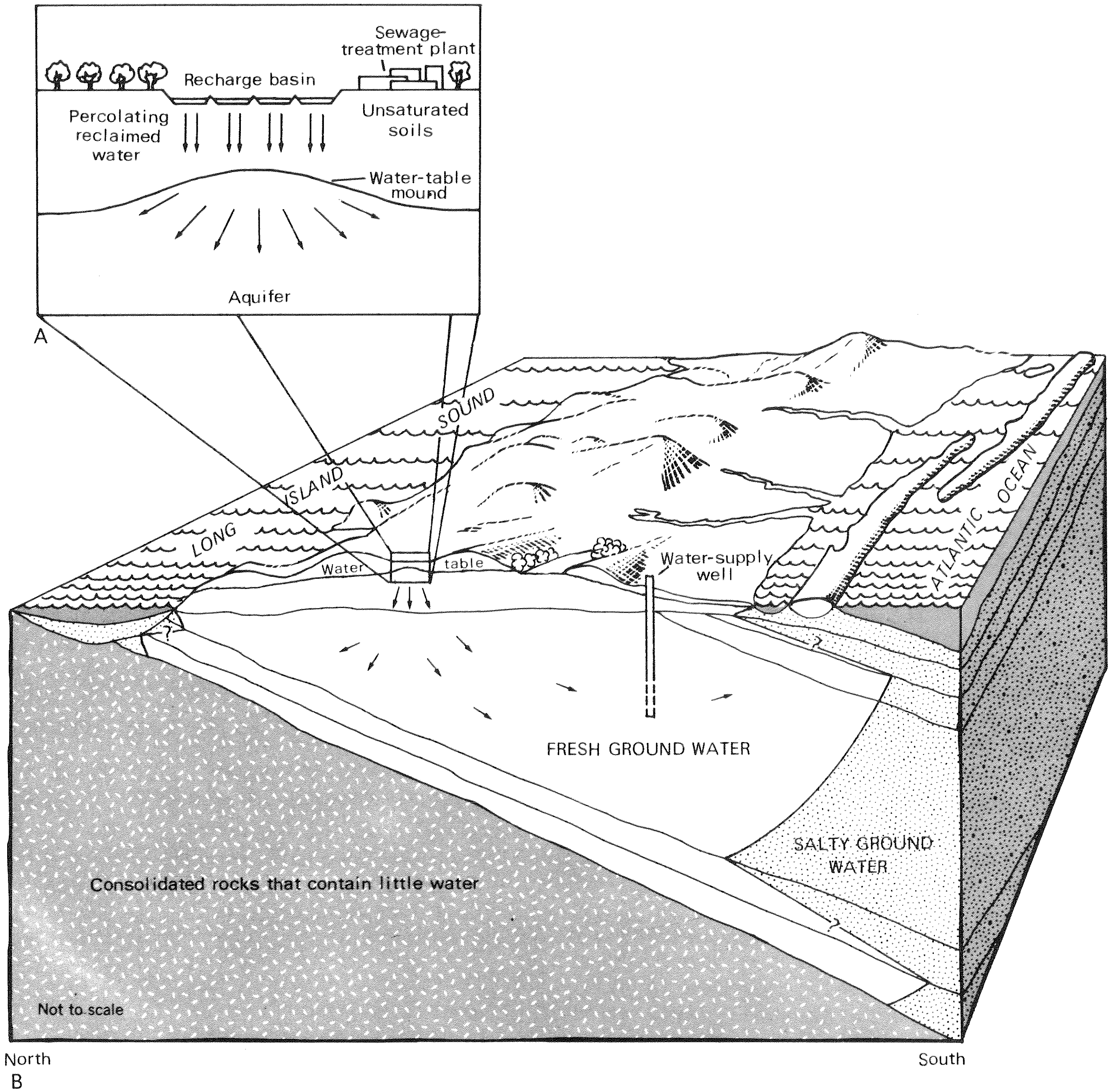

Figure 8.--Cross section of Long Island showing (A) water-table mound that develops beneath a recharge basin during infiltration, and (B) flow directions of reclaimed water from recharge basin. [Modified from Cohen and others, 1968.]

FUTURE OF ARTIFICIAL RECHARGE ON LONG ISLAND

Most water managers expect that consumption of water on Long Island will increase rapidly in the near future, and some predict that industrial requirements will more than double within a few decades. Thus, it can be expected that withdrawals from Long Island's ground-water reservoir will greatly increase, that expanded sewering will further reduce recharge, and that the need for additional sources of usable ground water will be intensified in years to come.

Several remedial measures have been and are now being used in Nassau and Suffolk Counties to conserve local or regional ground-water resources. A pilot research project near the village of Medford in Suffolk County is investigating the use of reclaimed water for artificial recharge through basins, with particular emphasis on the role of the soil in controlling recharge rates and on improving the quality of reclaimed water as it percolates downward. A part of the facility designed for this study is shown in figure 9.

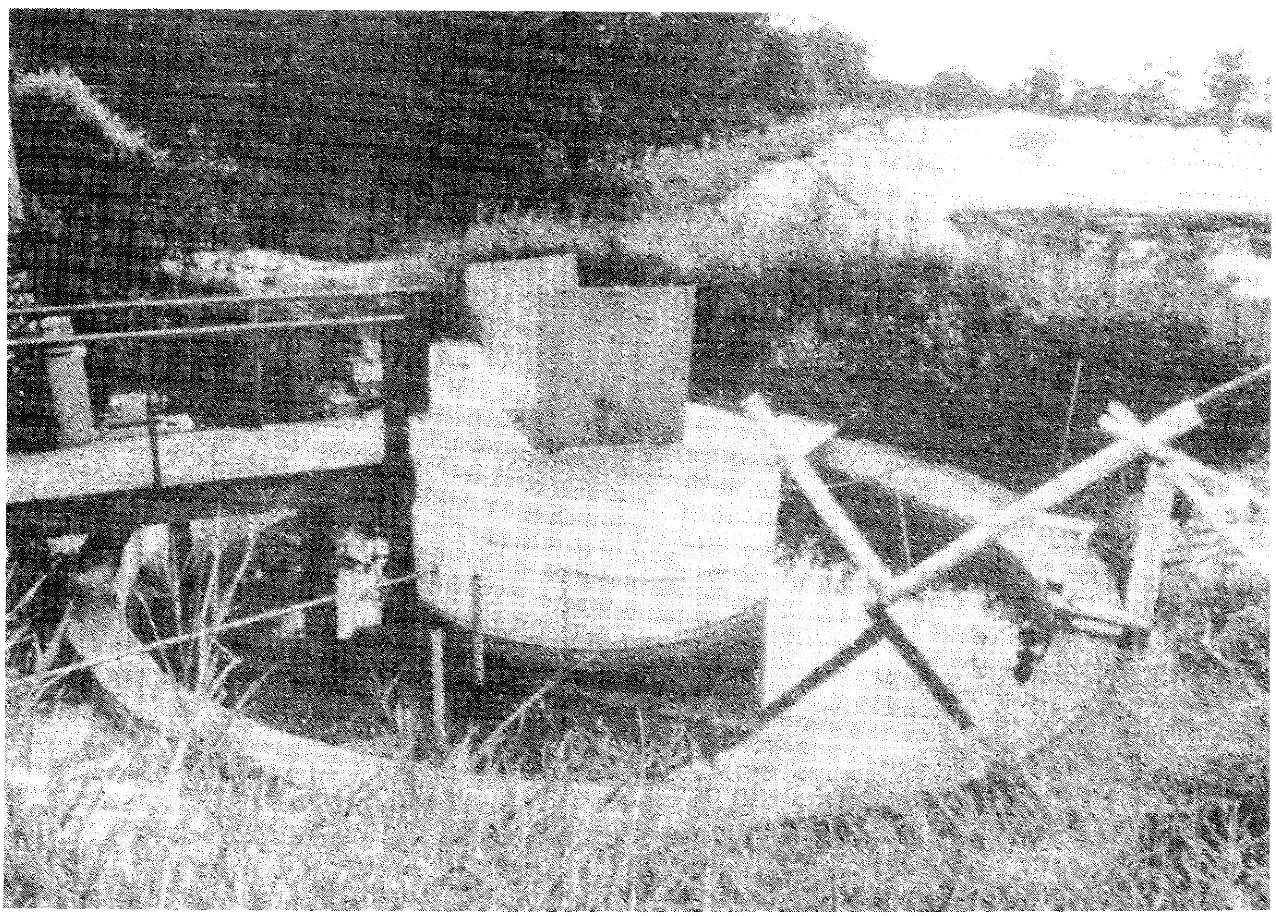

Figure 9.--Observation manhole in reclaimed-water basin at Medford installation, Suffolk County. Part of a recharge basin for disposal of treated wastewater is in background.

Nassau County has developed a long-term program to ensure an adequate water supply for the future. An important part of the program involves recycling reclaimed water and includes a short-term demonstration project in which a water-treatment and ground-water-recharge operation capable of handling 5.5 million gallons per day will be tested for performance and reliability. Reclaimed water is to be supplied by the water-reclamation facilities at the Cedar Creek Pollution Control Plant and will be piped to injection wells and recharge basins at the Meadowbrook artificial-recharge site at East Meadow. (See fig. 3.) Principal goals of this project are to evaluate the legal, esthetic, economic, and technical feasibility of advanced wastewater treatment for use in artificial recharge.

Present artificial-recharge installations on Long Island are the experimental basis for development of systems that will provide maximum recharge at low cost on the smallest acreage, to help protect and preserve the island's ground-water supply in coming decades.

SUMMARY

Ground water is the sole source of fresh water for the residents of Nassau and Suffolk Counties on Long Island. In these counties, the ground-water supply has been diminished by (1) the demands of continued population growth and (2) the loss of replenishment through the increasing disposal of wastewater and storm runoff to coastal waters. In addition, the quality of ground water is threatened locally by infiltration of septic-tank, cesspool, and industrial effluents and by salt-water intrusion near the shorelines as a result of heavy pumping for public water supply.

The use of highly treated wastewater (reclaimed water) to replenish the ground-water supply seems to be both feasible and economical. Two methods that are particularly well suited to Long Island are surface ponding of reclaimed water in basins so that it can infiltrate to the water table, and injecting reclaimed water into the ground through wells. Major hindrances to these procedures are clogging of the infiltration surface of basins and well clogging by suspended particles in the injected water. Infiltration rates of basins and injection rates at wells can be maximized by proper maintenance and by suitable treatment of the reclaimed water before recharge.

Artificial recharge on Long Island depends on sewage-treatment systems that are designed and operated to produce reclaimed water of high quality. Adverse affects of artificial recharge can be minimized through monitoring (1) chemical quality of reclaimed water as it is injected and quality of the replenished ground water; (2) water-table altitudes as they rise in response to recharge, (3) changes in streamflow and in chemical quality of streams near recharge sites, and (4) chemical quality of coastal waters.

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